

Thermodynamics

- state the first law of thermodynamics (statement).
- proofs.
- solve examples.

→ First law of thermodynamics

ΔE : change in internal energy ($K.E + P.E$)
 ΔH : change in enthalpy ($\Delta E, q, work$)
 q : Heat

→ law of conservation of energy

- Work and Heat are both forms of energy.
- Any form of energy can be converted to another form.
- Energy can't be created nor destroyed.

→ Proof:

- If we have a system of Internal energy (E_i)
- If the system absorbs (endothermic reaction and $\Delta H = +ve$) quantity of Heat (q)
- Then the energy of system will be ($E_i + q$)
- If the system use some of it's energy to do work (w)
- Then, final energy of system $E_f = E_i + q - w$

$$\therefore E_f - E_i = q - w$$

$$\boxed{\Delta E = q - w}$$

Take into consideration signs

q is : (+) when system absorbs heat.
(-) when system evolves heat.

w is : (+) when the work done by system.
(-) when the work done by system.

at constant Volume: (bomb calorimeter)

Hence, $V_1 = V_2$ so $\Delta V = 0$

$\therefore W = \text{Zero}$ as ($W = p \Delta V$)

$$\Delta E = q_v \Rightarrow \text{only per 1 mole}$$

q_v : amount of heat evolved or absorbed at Const. Volume.

Note : Any heat q of Reaction at Const. Volume is represented by ΔE

ex comb. 5 gm of X at Const. Volume evolves 50 J. \rightarrow calculate q_v , ΔE .

$\rightarrow q_v = -50 \text{ J.}$ (-ve as system evolves heat).

$\rightarrow \Delta E$: If X is NaCl

5 gm $\rightarrow -50 \text{ J}$

1 mole $\rightarrow ??$ $?? = \Delta E$

58.5 gm $\rightarrow ??$

Note : If the given is **5L** turn it into grams.

→ AT Const. Pressure

Note All Reaction are made at Const pressure.

$w \neq \text{Zero.}$

$$\Delta E = q_p - w.$$

q_p : amount of heat evolved or absorbed at Const. pressure.

$$q_p = \Delta E + w. = \Delta E + P \Delta V$$

∴ The thermodynamic function H .

$$H = E + PV$$

$$\begin{aligned} q_p &= (E_2 - E_1) + PV_2 - PV_1 \\ &= (E_2 + PV_2) - (E_1 + PV_1) \end{aligned}$$

$$\therefore q_p = H_2 - H_1$$

$$\therefore \boxed{q_p = \Delta H} \Rightarrow \text{per one mole.}$$

Note

1) one mole : $\Delta E, \Delta H$ } Heat of
more than one mole : q } Reaction.

2) at Const. Volume:

at const. pressure: ΔH

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→ Heat of Reaction

explained by Note 1, 2).

- If V_A and V_B are the volumes of gases Reactants A and product B.

- If n_A and n_B no. of moles of gases Reactants A and products B

$$W = P \Delta V = P(V_2 - V_1) \quad ; PV = nRT$$

$$W = n_2 RT - n_1 RT$$

$; R, T, \text{const.}$

$$W = (n_2 - n_1) RT$$

$$W = \Delta n RT$$

$$\therefore \Delta H = \Delta E + W$$

$$\therefore \underline{\Delta H = \Delta E + \Delta n RT} \Rightarrow \text{gases only.}$$

Summary

$$\rightarrow \Delta H: \Delta H = \Delta E + \Delta n RT$$

$$\Delta H = \Delta H_{f(P)} - \Delta H_{f(R)}$$

$$\rightarrow \Delta E: \Delta E = q - W$$

$$\Delta E = q_v \rightarrow \text{per one mole.}$$

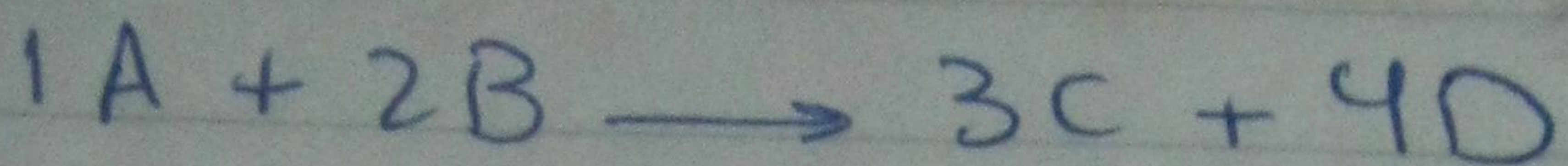
$$\Delta n = n_P - n_R \rightarrow \text{Gases only}$$

- To solve any problem:

1) write the equation (Reaction of system).

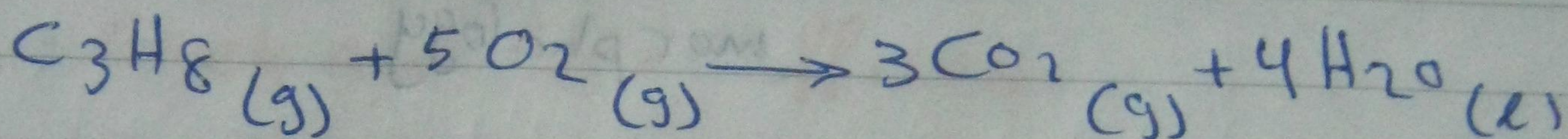
2) balance Reactants and Products.

3) Determine the type of material.



Notes → The number of moles of A must be one mole as it is the basic Reactant which I follow.

→ ΔH_f (each element) = zero.



$$\Delta H = 3\Delta H_f(CO_2) + 4\Delta H_f(H_2O) - \Delta H_f(C_3H_8) - 5\Delta H_f(O_2) = \Delta H_f(O_2) = 0$$

→ Δn : Take into consideration if Reactant and product are (solid, liquid or gas).

→ ΔH : Don't take into consideration (solid, liquid or gas) but element or compound.

→ Δn : could be (+ve, -ve or zero).

→ Δn : solid or liquid = zero, but gas = ?? (value).

→ $R = 8,314$ Joule except for one case if $PV = nRT$